Spring 2008
Industry Study

Final Report

Space Industry

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SPACE 2008

The United States space industry delivers capabilities vital to America's economy, national security, and everyday life. America remains preeminent in the global space industry, but budget constraints, restrictive export policies, and limited international dialogue are inhibiting the U.S. space industry's competitiveness. To sustain America's leadership among space-faring nations, the incoming administration should update and expand U.S. space policies and regulatory guidance, prioritize national space funding, and promote greater international cooperation in space. These steps will strengthen U.S. space industry. They will also enhance U.S. national security, spur technological innovation, stimulate the national economy, and increase international cooperation and goodwill.

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Domestic

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Sea Launch, Long Beach, CA
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NASA Dryden Flight Research Center, Edwards, CA
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EADS-Astrium, Stevenage, England
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PRESENTATIONS AT ICAF

Futron Corporation
Satellite Industry Association
Euroconsult
Space and Missile Systems Center
European Space Agency, Washington Office
German Space Agency (DLR), Washington Office
Roundtable with Mr. Damon Wells (OSTP) and Mrs. Kim Wells (Dept of Commerce)

INTRODUCTION

> *In short, our leadership in science and in industry, our hopes for peace and security, our obligations to ourselves as well as others, all require us to make this effort, to solve these mysteries . . . for the good of all men, and to become the world's leading space-faring nation.*
>
> ***- John F. Kennedy (Rice University, September 12, 1962)***

The United States space industry delivers capabilities vital to America's economy, national security, and everyday life. America remains preeminent in the global space industry, but budget constraints, restrictive export policies, and limited international dialogue are inhibiting the U.S. space industry's competitiveness. To sustain America's leadership among space-faring nations, the incoming administration should update and expand U.S. space policies and regulatory guidance, prioritize national space funding, and promote greater international cooperation in space. These steps will strengthen U.S. space industry. They will also enhance U.S. national security, spur technological innovation, stimulate the national economy, and increase international cooperation and goodwill.

This report examines the global space industry, with an emphasis on the U.S. and European space markets. First, it describes the organization of the U.S. and European markets and the common segments of these markets. It then analyzes the current condition of the space-related industries that serve these markets. It highlights several examples of growth and innovation at home and abroad. Finally, in more detailed essays, this report examines challenges to U.S. space preeminence and it proposes recommendations that will build on our space heritage and fulfill President Kennedy's vision of America as the world's leading space-faring nation.

THE SPACE INDUSTRY DEFINED

The space industry is global, composed of individual firms and national and intergovernmental organizations that cooperate and compete in a worldwide space marketplace. This study focused on the dominant U.S. and European space markets and key participating firms within those markets. The U.S. and European space industries organize differently to pursue national space goals. The U.S. industry supports national security, civil, and commercial sectors depending on the particular space mission objectives. The European industry supports national, intergovernmental, and supranational sectors, depending on the mission and participation of European states.

Despite their organizational differences, the U.S. and European space industries include similar segments: payload, launch, control, and services. The payload segment includes those packages delivered to space to complete a mission. Satellite payloads include imagery, surveillance and reconnaissance, communication, position, navigation, and timing, and earth monitoring. This segment also includes deep space probes as well as payloads and crew to the *International Space Station (ISS)*. The launch segment involves activities required to deliver these payloads. This includes rocket and propulsion manufacturing along with the services to enable launch. The control segment includes telemetry and tracking of launch vehicles and payloads. Additionally it includes the tracking of space debris. The services segment encompasses activities provided to customers from space-based assets. This segment includes both commercial and government services such as communications and weather forecasting.

The number of nations significantly investing in their own space programs is growing. Countries such as China, India, Iran, Japan, Brazil, and Kazakhstan are actively expanding their reach and impact in the global space industry. This study did not examine these emerging space programs, but it does acknowledge the ascension of these markets and recommends their study in the near future. Within this scope, the following sections describe the current condition of the U.S. and European space industries.

CURRENT CONDITION OF THE SPACE INDUSTRY

Global Space Industry

The global space industry is a growing and important component of the world economy. The Space Foundation's *2008 Space Report* estimates global space revenues from government and private sources exceeded $250 billion in 2007, experiencing a solid growth rate of 11% from 2006.[1] A majority of the growth stems from U.S. Government spending (25%) and purchases of commercial satellite based products and services (55%). The U.S. continues to be a prime player in the global market, and opportunities grow as commercial services and products expand.[2]

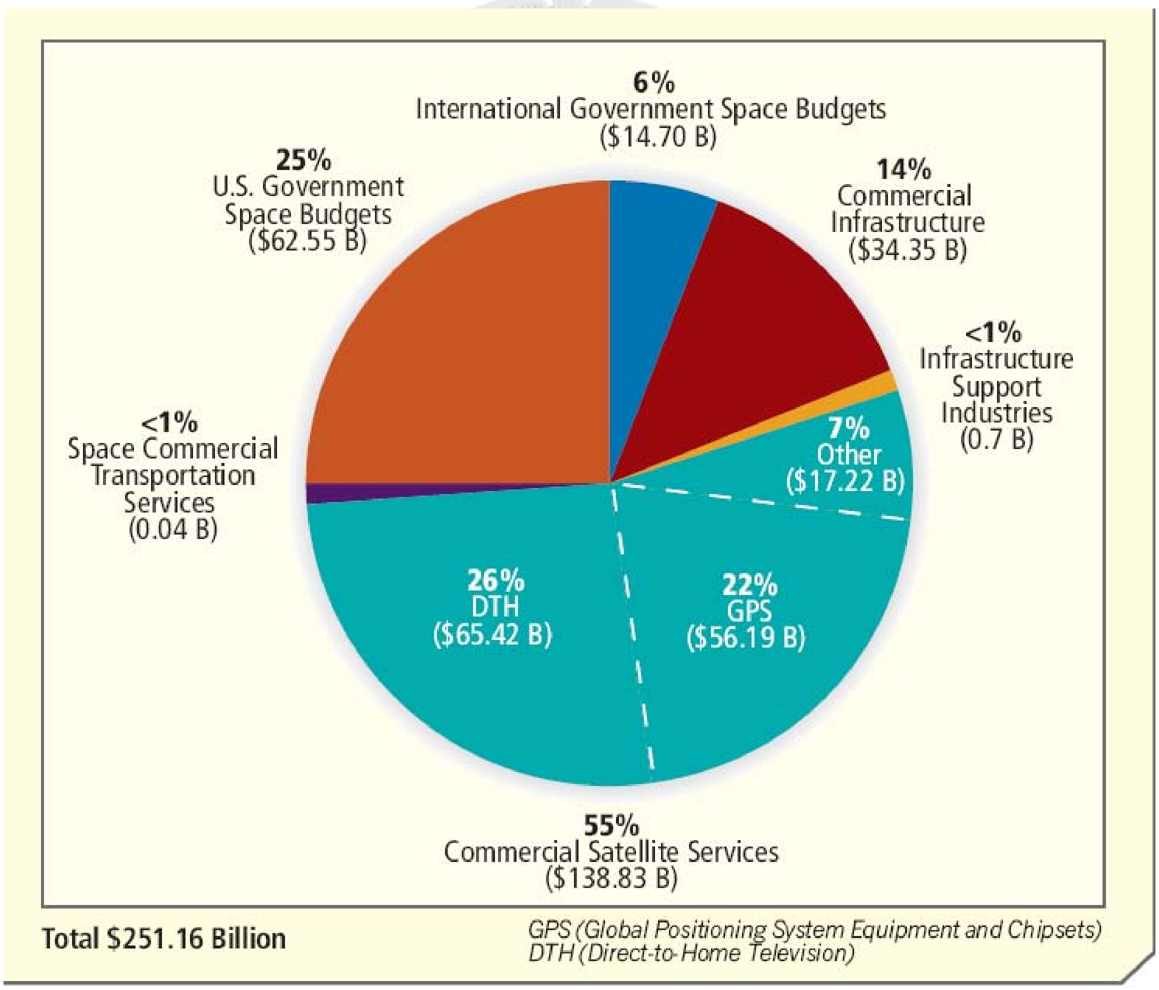

Figure 1. Global Space Activity, 2007[3]

U.S. Space Industry

The U.S. space industry is divided into three independent but interconnected sectors – national security, civil, and commercial. The dynamics between these three sectors drives the U.S. space industry. The national security space sector procures and operates space systems for communications, enhanced imagery, and intelligence collection. *U.S. Space Policy* directs the National Aeronautics and Space Administration (NASA) to lead U.S. civil space efforts. NASA develops systems for manned space travel, earth and planetary science research, and cargo delivery to the *ISS*. NASA's long-term goals, set forth in its *Vision for Space Exploration,* are intended to spark growth and innovation within the industrial base. In the commercial sector, customers acquire telecommunications, terrestrial imaging, and data transfer systems, sometimes supplementing military and intelligence systems. Space tourism is emerging within the commercial sector with the potential for rapid growth in the next decade.

While the U.S. space industry continues to experience revenue growth among the leading firms, there are strains in the launch and spacecraft manufacturing segments.[4] In manufacturing, U.S. firms continue to realize positive revenues based on national security orders.[5] In contrast, civil satellite orders, specifically from international consumers, have declined.[6] One message from industry was consistent — U.S. export policies are hampering U.S. industrial growth and expansion in the global economy. While the national security sector necessitates strict trade policies, increased regulatory flexibility in the civil and commercial sectors can enhance the U.S. position in the global economy.

European Space Industry

The European space industry supports national, intergovernmental, and supranational space goals as directed by national space agencies, the European Space Agency (ESA), and the European Union. The majority of European space activity is coordinated, organized, and executed through ESA.[7]

ESA is an intergovernmental organization that currently consists of 17 member states, with more states applying to join ESA in the near future.[8] Each member state contributes funding to ESA's budget in proportion to their gross domestic product. The nature of the organization requires consensus among the member states when deciding on space projects. Contracts are awarded to companies in each country in proportion to their funding contributions. This limits competition to within Europe and forms a barrier to entry to foreign firms.

ESA teams with NASA on some projects, but U.S. participation with ESA is limited due to strict American laws that prohibit the sharing of sensitive space technology. ESA leaders stated that ESA members would like to increasingly team with NASA on manned spaceflight missions, especially grand manned exploration missions like those outlined in NASA's *Vision for Space Exploration.*[9] This desire offers opportunities for increased U.S. – international collaboration on bold, and expensive, manned space exploration missions.

Following the global trend, the European space telecommunications market is expanding in size and technological complexity. In addition, ESA is pursuing its *Aurora* program for the exploration of the solar system, the *Galileo* global navigation system, and the *Global Monitoring for Environment and Security* program. Investment in national security systems is limited.

Similar to the U.S. space industry, the European space industry has experienced considerable consolidation in recent years.[10] A few large corporations are the primary service providers in the European space market. European Aeronautic Defence and Space Company (EADS) is the dominant satellite and launch provider. However, smaller companies such as

Surrey Satellite Technology, which specializes in micro satellites, are competing successfully in the global marketplace.

Payload Segment

The Satellite Industry Association and Futron, in their 2006 *State of the Satellite Industry Report*, highlighted a 6.7% growth rate from 2000 to 2005 for the worldwide satellite industry, with only the satellite manufacturing segment showing a slight decline.[11] Futron noted that market share is showing a shift from government to commercial satellite manufacturing and services. "Government payloads still constitute the majority of spacecraft launched. However, the absolute value of revenues from government payloads is declining at the same time that revenues from commercial payloads are growing."[12] The Space Foundation's *The Space Report 2008* indicates that these trends continued through 2007.[13]

The U.S. and European civil space sectors delivered several important payloads in 2008. The ESA sponsored *Columbus Laboratory* was carried aloft aboard America's *Space Shuttle* in February and was successfully attached to the *ISS*, where it is home to a multitude of science experiments. Launched on 9 March aboard an *Ariane 5*, ESA's *Automated Transfer Vehicle (ATV)*, known as *Jules Verne*, autonomously docked with the *ISS* on 3 April, completing the world's first fully autonomous docking in space.[14] The *ATV* will remain attached until September as it transfers cargo, fuel, and power to the *ISS*.[15] Finally, EUMETSAT's *Jason 2* ocean altimetry satellite will launch from Vandenburg Air Force Base, California in June.[16]

Launch Segment

Since 2001, worldwide launch revenues have remained relatively stable, ranging between \$2.7 and \$3.7 billion a year with U.S. revenues ranging from \$1 to \$2.1 billion per year during the same period.[17] The U.S. launch segment is an oligopoly that relies heavily on government demand, selling approximately 40 launches per year to Government agencies and only 20 launches to the private sector.[18] The U.S. launch segment is highly concentrated among a small number of competitors, defined by their capability and specialization.

Three aerospace companies provide launch services in the U.S. – United Launch Alliance (ULA), Sea Launch (a four-part international corporation with a 40% U.S. stake belonging to Boeing), and Orbital Sciences Corporation. A fourth company, SpaceX is attempting to break into the light-to-medium launch sub-segment by providing a low cost alternative, but it has not yet successfully launched a payload into orbit.[19] NASA awarded a launch service contract to SpaceX in anticipation of success.[20]

In the U.S., ULA and Sea Launch provide medium to heavy launch services. Former heavy launch competitors Boeing and Lockheed Martin formed ULA as a joint venture in response to lower than expected launch demand after the downturn in the commercial telecommunications satellite market in 2001. ULA is now the only U.S.-owned, heavy lift supplier. U.S. policy limits Sea Launch to commercial customers, because government satellites can only be launched from wholly-U.S. owned launch systems.[21]

Sea Launch and Orbital Sciences each provide unique launch services. Sea Launch uses a converted mobile oil platform as its launch facility and a ship as its control station. This mobility gives Sea Launch the ability to launch from the equator. Orbital provides a light to medium-lift capability using its air-launched Pegasus rocket and Minotaur and Taurus rockets.

EADS-Astrium is the primary European launch provider. The French-built *Ariane 5* is their heavy lift platform, with the Russian *Soyuz* and the Italian *Vega* (on-line in late 2008) as

their medium and light-lift platforms. Discussions with industry and government representatives in both Europe and the U.S. indicate concern about how much their respective governments subsidize commercial launch operations and how this affects international competition. Both markets are protected through various forms of government subsidies and regulation.[22]

Control Segment

Futron reports that ground systems accounted for $28.8 billion in satellite services revenue in 2006.[23] Satellite control facilities are emerging in office spaces as more countries and businesses place satellites into orbit. While the traditional locations for satellite downlink antennas remain relatively unchanged, new stations are being added along with technology that allows companies to remotely control their spacecraft using the Internet. Automation enables personnel to monitor numerous satellites using just one workstation in a control room. As these capabilities grow, information assurance will be essential and safe operations will also require standardized supervisory control and data acquisition protocols.

Services Segment

Commercial satellite services accounted for nearly $139 billion of global space revenue in 2007 (55% of global space activity).[24] The satellite services segment is growing as companies are developing new ways to exploit satellite technology for profit.[25] For example, DigitalGlobe and EUMETSAT are exploiting digital mapping, and weather observation, and they are selling their products to multiple commercial and government users. XM and SIRIUS, in the process of a merger, provide radio broadcast services to millions of users. Mobile Satellite Ventures is attempting to integrate satellite communications with cellular networks to provide expanded wireless coverage of North America. The Global Positioning System (GPS), a Government satellite constellation, accounts for 22% of global space revenue (over $56 billion).[26] Garmin and other companies have capitalized on the GPS network profiting by selling GPS devices to individual consumers.

U.S. GOVERNMENT ROLES IN AMERICA'S SPACE INDUSTRY

Appropriate Government support is critical to maximizing the potential of the U.S. space industry. Government agencies provide policy, leadership, guidance and invest fiscal resources. Where businesses sometimes focus on the short term, federal entities have the capacity to initiate and support higher risk and long-term programs. The Government can spur innovation in a fiscally responsible manner through development of dual-use technologies (*e.g.*, GPS). In its oversight capacity, the Government monitors on-going programs while also establishing and enforcing standards. Although the Government acts as sole agent, there are numerous agencies that share the role and burden of space research, operations, and oversight.[27]

The President's Office of Science and Technology Policy (OSTP) provides overarching scientific analysis and advice to the President, works with the private sector on science and technology efforts, and leads national science and technology policy development.[28] The OSTP led revisions of all U.S. national space policies in the last few years. The latest versions of these policies provide a solid foundation on which the next administration can build. The OSTP is preparing now for the transition to the next administration and the office will be the key coordinator of policies that will direct America's national space programs during one of the most challenging periods since the beginning of the Space Age.

Department of Defense's Role in the National Security Space Sector

Space assets directly support military operations. Communications, navigation, weapons targeting, intelligence, and reconnaissance rely on space assets. Department of Defense (DoD) dedicated satellite assets provide services and products that are generally unavailable to the public, the scientific community, or commercial enterprises. DoD is not normally involved in NASA's exploration or scientific missions, but DoD does support launch of NASA payloads.

DoD has a unique dual relationship with the commercial space industry as a customer and service provider. DoD acquires payloads and launch services, but also maintains the launch infrastructure used by the commercial sector. The national security space sector is so interconnected with civil and commercial space entities that all three must remain healthy and viable for national security space agencies to be effective.

In this regard, DoD should continue partnering with NASA and commercial space entities for the safe and reliable operation of launch facilities at Cape Canaveral Air Force Station and Vandenburg Air Force Base. The Air Force's telemetry and tracking roles will continue to be a part of its core missions and support of civil and commercial applications.

NASA's Role in the U.S. Civil Space Sector

The U.S.'s policy for civil space applications is derived from the National Aeronautics and Space Act of 1958, which established NASA to research flight within the atmosphere and in space.[29] NASA's mission is to lead U.S. space exploration, scientific discovery, and aeronautics research. Their mission functions include aeronautics, exploration systems, space science, and operations of existing systems such as the space shuttle. Some of the current missions include the *Mars Exploration Rovers*, *Cassini* in orbit around Saturn, the *Hubble Space Telescope*, and the *PHOENIX Mars Lander*, sent to explore the Martian arctic for signs of microbial life. The *ISS* established a permanent human presence in space, and NASA's Earth Science satellites deliver data on Earth's oceans, climate, and other features.[30]

Through the Centennial Challenge program and the Commercial Space Act, NASA provides cash reward and grant incentives to private citizens and private industry to innovate to meet challenging space flight goals.[31] NASA should increase this role to encourage a broader space entrepreneurial base in America.

EXAMPLES OF GROWTH AND INNOVATION AT HOME AND ABROAD

Commercial Launch Growth

There is significant potential for change in the domestic commercial launch industry over the coming decade. Euroconsult EC projects a 25% growth in the launch market with revenues of $12 billion USD.[32] Additionally, Euroconsult projects payload launches to geo-stationary orbit will continue to dominate, but as smaller launchers come online, the market share for low-earth orbit launches will increase.[33] Observations in both Europe and the U.S. suggest that medium to heavy-launch providers are operating at or near capacity. For many customers, particularly the Government, reliability and assured space access are more important than price.

In the U.S., NASA has taken some bold new steps in encouraging a competitive commercial market through the initiation of its Commercial Orbital Transportation Services (COTS) program, which incentivizes industry, with grants of up to $500 million USD, to provide new and innovative solutions for *ISS* re-supply.[34] Thus far, two companies have signed COTS contracts, SpaceX, and Orbital Sciences.[35] SpaceX is developing two new launch vehicles, the

Falcon 1 light lift and the *Falcon 9* medium-lift rocket. Orbital Science is developing the *Taurus II* rocket, using existing Ukrainian (*Yuszhnoe*) technology.

The European market will continue to use the *Ariane 5* rocket as the workhorse for most of its requirements. Currently the *Vega* rocket is under development for smaller launch requirements, with the first launch scheduled for late 2008.[36] ESA, however, has embarked on an ambitious program to address long-term launch requirements through the Future Launchers Preparatory Program (FLPP). To have a Next Generation Launcher operational by 2020, FLPP intends to make optimum use of available resources by leveraging European launcher technologies and encouraging the progressive restructuring of the European launch sector.[37]

Satellite Innovations

The satellite industry will continue to provide consumer communication, information broadband, data, position-navigation-and-timing, and entertainment delivery. Growth will occur as more people around the world connect through these media paths, driving the need for increased satellite production and launch services.

In addition to these traditional business lines, the commercial industry is working to extend the life of their satellites through innovation in power sources, more reliable components to allow reduced redundancy, use of lightweight materials, and more fuel-efficient engines. There is a potential market for a remote transfer vehicle, which captures a failed or expended satellite to repair it or extend its orbital life. A German company, Kayser-Threde, is exploring this opportunity.[38] Its On-orbit Life Extension Vehicle (OLEV) will have the capability to extend the life of a satellite that has expended its own maneuvering fuel by attaching a maneuvering engine with additional fuel. Another potential application for these automated vehicles is the salvage of debris or dead satellites.

Advances in satellite technology will focus on enhancing data transfer capacity through space and creating efficiencies that will lower the cost of business. Discussions with U.S. satellite industry professionals indicate that it is not profitable for them to engage in technology research, but in Germany, the German Space Agency's Institute for Robotics and Mechatronics is working on just such innovative opportunities.[39] The U.S. government could fund similar efforts and achieve the dual purpose of fulfilling requirements and strengthening the U.S. satellite industry. Manufacturers need the government to take the lead promoting innovation.

New Capabilities in Low Earth Orbit

European companies are making low-cost microsatellites (Surrey Space Technology in England) and using satellite laser communications to alleviate spectrum congestion issues (Germany's DLR Institute of Communications and Navigation). The ESA is aggressively moving forward to develop and employ the *Galileo* satellite-based navigation system, similar to the U.S. GPS. Two testbed satellites are now in orbit. The full constellation will include 27 active and 3 reserve spacecraft, with the initial 4 satellites scheduled for launch in 2010.[40]

Due to the scheduled retirement of the *Space Shuttle* in 2010, the U.S. will soon have a gap in its capability to transport supplies to the *ISS*. To overcome this gap ESA created the *ATV*. The *ATV* is an unmanned cargo craft that is capable of autonomous rendezvous and docking with the *ISS*. The *ATV* had its first successful *ISS* rendezvous in April 2008.[41]

Demands placed on the radio spectrum are driving innovation in laser space communications. Laser communications offer alternatives for satellite-to-satellite cross-link and satellite up/down-link communications. Significant challenges exist for both endeavors, the

most daunting of which is laser penetration of the earth atmosphere and weather. The German Space Agency is one organization conducting experiments to refine laser communications.[42]

Innovative Space Companies – A Dying Breed?

Two of the most innovative companies visited were Scaled Composites of Mojave, California, and Surrey Satellite Technologies of Guildford, England. Both companies share an impressive record of accomplishment and successful innovation over the past thirty years, Scaled Composites with aircraft and civilian spacecraft and Surrey Satellite with small and micro-satellites. Both companies employ about 300 people and both nurture a close and creative environment. Both also became acquisition targets for much larger space companies over the past year. In August 2007, Northrop-Grumman acquired Scaled Composites.[43] EADS-Astrium is currently trying to purchase Surrey Satellite Technologies.[44] It is critical that the innovative spirit of these unique companies is preserved in their mergers with the larger companies.

Space Tourism – An Emerging Service Segment

The space tourism market has grown from fanciful ideas a decade ago to flyable spacecraft today. Market analysis predicts strong growth over the next decade. A thriving space tourism market will benefit the U.S. economy, and it will inspire future generations to pursue math, science, and technology careers.

In their updated 2006 forecast, Futron projected initial suborbital flights to begin in 2008 and passenger demand to grow from a few hundred passengers at the start to just over 13,000 by 2021.[45] The first commercial suborbital flight should occur by 2010. Futron also forecasts the ticket price to drop from $200,000 initially to $50,000 by 2021 opening up space tourism to a much wider population.[46] Using projected passenger demand and ticket prices, Futron forecasts that suborbital space tourism could generate just over $100 million the first year of flight and then grow steadily to nearly $700 million in annual revenue by 2021.[47]

Six commercial spaceports are operating today with more planned in the coming decade. One planned spaceport will be home to Virgin Galactic, a European company and the leading candidate for the first suborbital space tourism operation. They will base their operations at a brand new spaceport in New Mexico called Spaceport America.[48] An economic impact study by Futron Corporation estimates that by 2020, as many as 426 suborbital space flights a year will launch from Spaceport America.[49]

The U.S. Government should promote the growth and safety of this emerging market but avoid over regulating, which can stifle the risk-taking necessary to launch space tourism.

CHALLENGES FOR THE U.S. SPACE INDUSTRY

The U.S. space industry is characterized by limited competition and innovation. Customers typically value reliability, with its inherent high cost, over innovation and potentially lower costs. Faced with slim profit margins, the industry has little incentive to invest in research and next generation technologies that could fire innovation and spur economic growth. The industry and the Government, as the primary customer and policy driver, face significant challenges, which limit the industry's ability to compete in a global marketplace and endanger the U.S.'s strategic advantage in space. Export controls are commonly understood to be impediments to industry competitiveness. However, the Government and industry will face a wider range of challenges including the control and de-confliction of an ever growing number of

satellites and spacecraft, the proliferation of space debris, and the potential militarization of space.

A Tightening Federal Budget and Low Public Interest Challenge National Space Projects

Resourcing space programs, primarily civil programs, is more challenging today than it was during the 1960's space race. Two challenges that face space supporters are fiscal constraints and the national will. Today, unlike the 1960s, non-discretionary spending is increasingly dominating the U.S. budget. Entitlement programs such as Social Security, Medicare, and Medicaid, and servicing the national debt are absorbing more of the Federal budget than at any other time in history. In 1967, during the height of the Apollo Program, mandatory spending was 26% of the Federal budget. Today it accounts for 53%.[50] Conversely, the discretionary spending has decreased from 67% to 38% of the federal budget over the last forty years.[51] Moreover, the Congressional Budget Office has projected that for the next 10 years, a critical NASA development timeframe, the yearly deficits will range between $300-500 billion,[52] dramatically expanding the national debt.

NASA cannot afford to absorb budget cuts if it is to keep on timeline in its effort to achieve the nation's space exploration vision and fulfill its obligations for its other core space missions. In February 2008, during a Congressional budget hearing, NASA Administrator Mike Griffin stated, "there is minimum flexibility, so Congressional support for budget stability is critical."[53] He has further stated that in order to preserve the moon program, NASA would be "reducing expected growth in science programs, cutting aeronautics research and delaying planned projects."[54] It is difficult to quantify the long-term impact, but one could rationalize that cuts in these programs will have an impact on the cultivation of future scientists and the advancement of U.S. space technology.

Despite the financial challenges, the country's national will to support civil space programs will determine if NASA will achieve its objectives. Without popular support, the Government will be less inclined to support the necessary budget for space programs. Today the American people are less focused on space programs than they are on programs that can address the current economic situation. Faced with this dilemma, it is imperative that space advocates educate the populace on the societal benefits of technology created to support space programs. The first essay in the next section explores this challenge and offers recommendations for the next U.S. administration to consider.

NASA's Gap Between the Shuttle Program Retirement and the Constellation Program

The Constellation Program is NASA's follow-on to the Space Shuttle for U.S. manned space flight. In February 2007, NASA Administrator Griffin testified to Congress that, "the greatest challenge NASA faces is safely flying the Space Shuttle to assemble the International Space Station prior to retiring the shuttle in 2010, while also bringing new U.S. human spaceflight capabilities on-line soon thereafter."[55] Facing budgetary limitations, NASA has developed a phased funding strategy, which allows Constellation to assume Space Shuttle resources as they become available. Even with this strategy, NASA projects a three- to five-year gap in U.S. human spaceflight capability between retirement of the Shuttle and the initial operational capability of the Constellation Program. In order to mitigate the gap in payload service to and from the ISS, the U.S. is exploring commercial launch technology. However, for manned transport, NASA's plan is to purchase transport on Russian human delivery capsules.[56]

Export Controls That Inhibit U.S. Competitiveness in the Global Space Market

America's export control efforts may be hampering continued U.S. advancements in space and space technology. Some representatives of U.S. and European companies argue that the International Traffic in Arms Regulations[57] (ITAR) and export controls, designed to protect the U.S.'s strategic advantage, have instead often reduced the U.S. strategic advantage by weakening our economic element of power, encouraging foreign development of technologies, and the growth of foreign competition.[58] In applying a cold-war era policy to a globalized industry, these regulations and policies may be partly responsible for shrinking the U.S. space industry's global market share. Furthermore, these controls have not prevented others from acquiring increasingly sophisticated space capabilities often rivaling or surpassing our own. The intent of ITAR and export controls is sound, but they burden U.S. space companies through inefficient implementation and processes. The second essay in the next section of this report examines this issue and offers recommendations for improvements.

Outdated International Space Treaties, Laws and Regulations

The number of countries actively pursuing a presence in space is growing and requires the international community to ensure that the legal and procedural groundwork is current and relevant. Currently the United Nations has 16 international agreements relating to space activities. However, six major agreements were signed in the late 1960s and early 1970s, and they many not adequately address the challenges and complexities of today's space environment. The U.S. must take a leading role in reviewing and updating these agreements; otherwise, it will face the prospect of the international community creating treaties that are not in the U.S. national interest. The third essay in the next section analyzes this issue further.

Space Control in a Crowded Space Environment

Dynamic space operations are likely to involve the movement and control of multiple spacecraft operating in near proximity during simultaneous missions. As these vehicles cross paths with other satellites and spacecraft, communications frequency interference is sure to occur. This environment will require amending our policies to enable the development of a global network capable of dynamically assigning, reassigning, masking, and distributing frequencies to ensure positive control. The third essay in the next section examines the space control challenges and proposes a space control paradigm to address the challenges.

Militarization of Space

The recent successful destruction of a disabled U.S. satellite by a missile launched from a U.S. naval vessel and China's anti-satellite test last year have reinvigorated the long-standing debate over whether or not to militarize space. Given these current developments, the next administration will likely have to refine the U.S. position regarding the militarization of space. The fourth essay in the next section presents a detailed analysis of this issue and offers a policy recommendation for the next administration to consider.

ESSAYS ON MAJOR ISSUES

ESSAY 1: Resourcing our National Space Policy

Space assets figure prominently in the U.S. military's ability to fight and defend around the globe. Many proclaimed the first Gulf War as the "first space war,"[59] and now all Defense operations require direct support of space assets. The result is a dependency on more reliable and available space capabilities. In order to retain and improve on these capabilities, Congress and Defense must address the challenges in resourcing critical space systems.

U.S. Defense Space Resourcing

It is obvious when examining the size of future defense acquisition budgets and the cost performance of existing space systems that Defense has too many large programs competing for too few dollars. Of course, Congress authorizes and appropriates funds for these programs and bears some responsibility; however, Defense must be a better steward of taxpayer dollars while meeting the warfighters' needs. As the Government Accountability Office points out, having too many programs creates "a set of incentives and pressures that invariably have negative effects on individual programs and the larger investment portfolio."[60]

The unstable budgets approved by Congress make planning extremely difficult for contractors and Defense planners, which result in increased costs and risks. Finally, the lack of a true management reserve (MR), funds available to address legitimate problems and cost overruns, makes it difficult to manage complex programs. The 2003 Young Panel review recommended true MR for space programs[61] and Under Secretary of the Air Force Teets insisted on a MR for the Space Based Infrared System to deal with challenges.

With regard to many Defense programs, both Defense and Congress need to face the reality of limited defense budgets and make hard choices. Some programs will have to be cancelled, extended, or modified significantly. This will take leadership and political courage.

Following this first difficult step, Congress and Defense need to fully and realistically fund vital space programs. The U.S. cannot afford to pay for all that is currently programmed. Congress should consider coming up with a more stable funding strategy such as pegging defense spending at a certain percent of GDP. This could provide increased stability. A former space acquisition commander recommended the following method for improved cost estimating. Prior to releasing a request for proposals (RFP), Defense could consult with key interested contractors and independent Defense cost teams to develop a realistic total acquisition program cost. Next, Defense could release the RFP requiring all bidders to only focus on the non-cost aspects of their bid, and then hold the winner to the estimate. This effort could reduce the incentives for the contractors to submit artificially low bids to buy into an acquisition program. Source selection criteria would not include cost, but instead would focus on past performance and the technical merit of the proposal. Ensuring adequate execution-year reserves for space acquisition programs would provide leadership with the means to address normal program perturbations.[62] Unavailable MR forces program managers to make poor decisions and increase risk by moving funds from one part of a program to another.

NASA Budget Challenges

In 2004, the President released his vision for manned space exploration calling for a return to the moon by 2020. The Constellation Program answers the challenge to provide a low-

Earth orbit capability to replace the Space Shuttle. However, if current trends continue, funding constraints could jeopardize the timely realization of these national goals.[63] Efforts to increase NASA's budget and solidify international participation have met with Congressional opposition.

NASA's budget to cover the initial phases of the program is roughly $9 billion over the next three years, but will increase to $8 billion per year following the retirement of the Space Shuttle. This funding effort focuses on the transportation aspect with little dedicated to surface operations on the Moon and Mars.[64] With the current budget and technical base-line NASA acknowledges there is only a 65% confidence level that the Constellation Program will meet schedule commitments.[65]

The Fiscal Year 2007 appropriations bill slashed NASA's budget by over half a billion dollars with many of the cuts directed specifically at human spaceflight. NASA Administrator, Michael Griffin, testified, "This reduction may significantly impact our ability to safely and effectively transition…" The War in Iraq, burgeoning health care costs, and the recent housing crisis, have all taken budget priority over Constellation. It is apparent that current public opinion is insufficient to compel Congress to provide significant funding for Constellation.

President Bush called for international participation and NASA is anticipating it, but no formal agreements have been reached.[66] Michael Griffin is attempting to build on International Space Station partnerships. In July of 2006 he appealed to "…the leaders of the world's space agencies to join NASA in its bid to send astronauts to the Moon and Mars."[67] France and China have both expressed interest in fostering international partnerships for manned space exploration.[68] Unfortunately, restrictions (such as ITAR) continue to limit partnering efforts and with fears of a "Space Pearl Harbor," engagement with China has met significant opposition in Congress. However, the benefits of global participation extend beyond economic, as Gregory Metzler suggests, "Perhaps a U.S.-China Moon mission or international mission to Mars could serve as a vehicle for promoting international cooperation…"[69]

In the midst of budget constraints and a struggling economy, it will be difficult to fund NASA's bill for science and exploration. It is more likely that public opinion would support a plan with international partners sharing the enormous cost to send humans to the Moon and Mars. It is vital for the American public to be educated and excited about the importance of this critical step for science. Encouraging all countries to join the effort extends an unprecedented collaboration opportunity that allows the world to explore the heavens in the name of Mankind rather than as individual countries. It also allows the United States to further its unique, but deteriorating, role as the world's leader in space.

Authors: Col Michael Miller, USAF and CDR Lyle Stuffle, USN

ESSAY 2: Impact of Export Controls on U.S. Competitiveness in the Global Space Market

Many nations, including the U.S., place rigorous controls on the export of certain products, technologies, and services reflecting national security and foreign policy concerns.[70] The U.S. has the world's greatest technology-innovating economy[71] which depends on the export of these very products, technologies, and services.[72] However, export controls, designed to protect the U.S.'s strategic advantage, may reduce our advantage if not properly implemented. A weakened economic element of strategic power, both absolutely and comparatively, encourages foreign development of the very technologies export controls were designed to protect, fostering the growth of foreign competitors, and thwarting research and investments in U.S. industry.

The U.S. regulates space technology exports to preserve its strategic advantage. Space technology, once predominantly the realm of government-built systems for military or intelligence use, is now an industry increasingly dominated by commercial activity. Exports are critically important to the space industry, particularly the U.S. industry, as it does not have the same direct government support received by its foreign competitors and must depend on private markets for financing and revenue.[73]

"America's advanced technology industries … are uniquely aligned with our strategic national interests"[74] and those interests require "major changes to the U.S. export control regime … to ensure that it reflects both current global market realities and America's strategic policy imperatives."[75] In the globalized world, satellites and space services are available from foreign sources. Restrictive export policies potentially limit U.S. influence in shaping the global satellite and space services market, without denying other nations access to space technologies.[76]

The premise that export controls actually hurt security is arguable but comparing foreign and U.S. space industries provides interesting insight. There has been growth in the number of foreign companies, and their market share, supplying communications, remote sensing, and navigation satellites, while U.S. industry market share shrinks. The intent of export regulation is sound but its implementation and methods should be improved to ensure effectiveness and efficiency. It has not prevented others from acquiring increasingly sophisticated space capabilities often rivaling or surpassing our own. Failing to keep space technology export regulations current and relevant may cost the U.S. its lead in space and space technology.[77]

U.S. businesses must comply with applicable export controls for their products.[78] The U.S. Government controls exports on a product-by-product and case-by-case basis,[79] regulated by a myriad of federal agencies and administered by a wide range of regulations. The regulations most applicable to the space industry are the International Traffic in Arms Regulations[80] (ITAR), administered by the Department of State, and the Export Administration Regulations (EAR),[81] administered by the Commerce Department.

The ITAR is a set of regulations that governs military[82] and space-related[83] exports of goods and technologies. The U.S. Munitions List (USML),[84] part of the ITAR, identifies these articles and services, and divides them into twenty-one categories,[85] two of which, "Launch Vehicles, Guided Missiles, Ballistic Missiles, Rockets, Torpedoes, Bombs, and Mines,"[86] and "Spacecraft Systems and Associated Equipment,"[87] are related directly to the space industry. No defense article, defense service, or technical data may be exported without a license from State.[88] Obtaining this license takes time and resources. U.S. companies, and their customers, must account for this in consideration of delivery time and overall cost, particularly for foreign customers.[89]

The EAR is a set of regulations that governs the export of dual-use technologies[90] having "both commercial and military or proliferation applications."[91] The Bureau of Industry and Security (BIS) at Commerce administers the EAR,[92] regulating exports in accordance with the rules for the subject technology[93] and nationality of the person to whom they are to be exported.[94] EAR export-restricted-technologies[95] of most import to the space industry include propulsion systems, space vehicles, and related equipment.[96]

U.S. industry argues that export controls have diminished their world market share of space equipments, particularly satellites and satellite technologies, to the benefit of foreign firms and have provided encouragement for new foreign entrants into the business. Foreign firms are leveraging their "ITAR-free" advantage to offer customers faster delivery of products. European satellite companies have been designing satellites without U.S. components; France launched the first ITAR-free satellite in April 2005.[97] International customers can look to non-U.S. manufacturers to

deliver equipments faster and cheaper partly because their governments do not regulate space exports as munitions. U.S. firms argue that foreign governments favor non-U.S. firms in the contracting process by setting deadlines and goals that cannot be met if ITAR approval is required, effectively creating a non-tariff barrier against U.S. firms.[98] A recent industry survey captured information related to the added costs and unintended consequence of export controls.[99] It found:

License Process Issues—Impacts of export control processes vary by tier. Although less than 1% of ITAR license applications were denied in the 2003–2006 timeframe, the reported loss of foreign sales due to ITAR was $2.35B, mainly due to lengthy processing times;

Cost of Compliance—Export control compliance costs averaged $49M/year industry-wide, growing 37% during the 2003–2006 period with the burden higher for lower tier firms; and

Unintended Consequences—Foreign competitors leveraged their countries' more relaxed regulatory climates in marketing their products as "ITAR-free." Some U.S. companies claimed the European Space Agency (ESA) directed European companies to find non-U.S. sources for space products. ESA has also funded development of competing products to either avoid ITAR requirements, develop indigenous capabilities, or both.[100]

The U.S. space industry understands and supports the need for reasonable export restrictions balanced against the realities of the world global market.[101] Various organizations have suggested balanced solutions to the satellite export control issue and have enumerated many specific legislative or regulatory actions.

After the 2008 elections, the new administration and Congress will have the opportunity to consider export controls reform. There is, therefore, some possibility of implementing, or continuing support for, some of the following beneficial changes:

- Providing more export licensing officers at State;
- Streamlining the list of technologies requiring ITAR review;
- Reconsidering Commerce oversight of satellite export control instead of State;
- Considering a "certified exporter" program which would approve companies to export satellite technologies rather than individual transactions; and
- Loosening the restrictions for exports to NATO allies.[102]

It is clear that the current interpretation and implementation of export control legislation is impacting the economic element, and not properly balancing it against other elements, of national strategic power. The approximately 1% application rejection rate indicates it is the delay and uncertainty rather than aggressive industry reaching or expansionistic interpretation that is the problem. To improve our global advantage in the space industry, we should ensure that:

- State has the resources to accomplish timely ITAR license reviews or return jurisdiction to Commerce;
- in recognition of space technology globalization, we limit the USML to technology which transfer poses a real security threat, and has not already been developed by foreign powers;
- we negotiate treaties with our economic allies and NATO that allow for the free exchange of space items and technologies in all but the most critical cases; and
- finally, we follow the balancing test written into our export control laws and "use export controls only after full consideration of the impact on the economy of the United States and only to the extent necessary."[103]

Author: Mr. Stephen Bloor, DoD

ESSAY 3: Space Treaties, Laws, and the Need for Improved International Governance

Current international regulations governing space operations are old in terms of space history, and should be updated in view of the growing involvement in space by new nations. As the world's leader in space, the U.S. is poised to shape the future space regulatory landscape. Now is the time to review our agreements, treaties, and regulations as the number of space players continues to increase.

The U.S. is involved with a number of international agreements that can be divided into United Nation (UN) resolutions, multilateral and bilateral treaties. As of January 1, 2008, the UN had 16 international agreements relating to activities in outer space.[104] Six major agreements were drafted and signed in the early days of space exploration during the 1960s and 1970s. In addition, the United States has also negotiated space regulations via bilateral and multilateral agreements.[105]

Organizationally, the International Telecommunication Union (ITU) is the United Nations agency that "manages, among other issues, the geostationary orbital-slot assignments, as well as frequency allocation for its international member states."[106] The United Nations Office for Outer Space Affairs (UNOOSA) is the office responsible for promoting international cooperation in space. These agencies are some of the very few that exist which can provide a globalized structure to space efforts. Within the U.S., multiple agencies have a role in providing a regulatory framework for U.S. operations in space.[107] The myriad of responsibilities spread over such a diverse group of agencies is inefficient and not conducive to facilitating operationally responsive space missions.

As commercial vendors seek to build upon capabilities that will allow human travel and increased robotic operations in space, the U.S. must adopt a policy that enhances the network of command and control that connects our spaceports, ground, and control stations together. Maintaining situational awareness that includes space weather, communications, navigation, clearance from space debris, electromagnetic interference, and an awareness of other spacecraft is essential to ensuring safe space operations. "The space domain is still vast, but certainly not as empty as it used to be – there are currently over 15,000 artificial objects in space to include everything from active satellites to launch-related debris. This increasing number of objects increases the potential for a catastrophic collision in space and the potential threat to billions of dollars worth of national assets, DoD payloads, commercial space satellites, and manned space systems."[108] Today, the number of simultaneous space flight operations remains relatively low and controllers do not have to actively synchronize missions. As the commercial market expands and launches increase in frequency, the existing infrastructure to control space flight will be required to undergo significant improvements to ensure safe multi-ship space flight operations.

To mitigate the risk of spacecraft colliding with each other or accidentally crashing into space debris, an improved ground control system must be developed. The characteristics of the system will need to include launch coordination capabilities, in-flight maneuvers, tracking telemetry and collision avoidance, as well as, search, rescue, communications, and weather. Prior to a launch, coordination must occur to de-conflict frequencies, spacecraft trajectories, low-earth orbiting satellites, debris, and other scheduled flights. As multiple rockets begin to launch simultaneously, spacecraft control will become increasingly more complex and require pilots and controllers to synchronize transit corridors while maintaining situational awareness. The development of this system requires cooperation, standards, teamwork, and policy.

The Federal Aviation Administration is already designating spaceports across the U.S. It operates an international model of air traffic control that could serve as a template for an integrated, intelligent space architecture. The U.S. should develop a national network capable of performing these tasks within an international framework. Attaining this goal is vital to developing a comprehensive policy that can enable future space operations.

Space control is one of many regulatory challenges. The U.S. is the world's leader in space, and it should leverage its position to advance space regulations. It is time to engage the international community and develop binding space laws modeled after past efforts in maritime law. In particular, the United Nations Convention on the Law of the Sea (UNCLOS) could be a model for a future Law of Space. Conventions such as Collision Regulations (COLREGS), International Aeronautical and Maritime Search and Rescue Convention (IAMSAR), and Safety of Life at Sea Convention (SOLAS) all have strong international support and could translate well to space applications, particularly for earth-orbit space.

Regulatory challenges include automatic identification, better tracking, detection devices, and dealing with space debris. "The U.S. must participate actively in shaping the space legal and regulatory environment."[109] The sheer number of satellites being acquired by an ever-increasing number of national and industrial players makes it important that the U.S. exert its global leadership to shape the policies on orbital control. In this effort, the United States needs to respond faster to changing global industry technology advances so that American companies can better compete as global leaders and innovators. An example of government regulation reform would be enhancing the Land Remote Sensing Act of 1992 to reflect current technologies so that U.S. companies can compete on an equal basis with international companies.

Equally, the U.S. must move quickly in shaping the global space regulatory environment. Nations developing new space capabilities will look toward the experienced space-faring nations for regulation and guidance, but the U.S. can no longer assume that they will wait for us to provide that leadership. The industry is growing quickly around the world, and without international and bipartisan leadership, others may seek their own regulatory framework to fill a needs vacuum.

The European nations have an existing framework of international cooperation to regulate space in the European Union, the ESA, and EUMETSAT. China will seek to fill the regulatory leadership position for different reasons and primarily to achieve its desire to be the premier global superpower. In the new era of globalization, space is a field in which the United States can unite all nations, as no other nation can, behind international cooperative efforts in advancing earth-orbit technology, science, and space exploration.

It is clear that we can no longer rely on past treaties, policies, and agreements for our future space requirements. Advancements in navigation, meteorology, communications, and earth observations are just a few of the evolving space capabilities that are essential to our national interest. America must act now and lead the world to frame the policies that will enable global prosperity and advance science for future generations.

Authors: Mr. William Walls, DOS; COL Welton Chase, USA; and CAPT John Carroll, USN

ESSAY 4: Weaponization of Space, Policy Implications, and Global Effects

On February 20, 2008 the USS *LAKE ERIE* launched a modified Standard Missile-3, destroying a disabled U.S. spy satellite more than 150 miles above the Pacific Ocean as it reentered the atmosphere.[110] This feat has reinvigorated the debate concerning the wisdom of pursuing policies and development efforts leading to a weapons capability in space.

The debate is not new. Since the beginning of the space age, people have wondered whether space would be weaponized and dominated by one powerful nation, or if it would become the common property of all humanity.[111] The next U.S. administration will grapple with this issue of whether or not to weaponize space. This essay reviews the major arguments for and against the weaponization of space, assesses several options available to policy makers in the next administration, and recommends a course of action to secure our nation's future in space.

Protecting Vital U.S. Interests

The U.S. is dependent on the unhindered use of space for its economic well-being and security. The U.S. National Space Policy states unequivocally that the United States considers space capabilities vital to its national interests.[112] Beyond military applications and security, space technology is used for many important purposes such as meteorology, environmental monitoring, disaster prevention, communications, entertainment, and observation. The loss or impairment of space capabilities could substantially harm the U.S. economically, militarily, and politically.[113] The main arguments for pursuing a weapons capability in space center on deterring and defending against any disruption of our Nation's continued peaceful use of space. The following list the supporting rationale.

Threat. Threats to U.S. space assets, both from the ground and in space, are real and growing. A number of states are developing capabilities that could place U.S. space systems at risk. [114] A dozen countries can now launch satellites, and potentially weapons, to space.[115] For example, China demonstrated an anti-satellite capability in January 2007 by shooting down one of its own weather satellites.[116] Although nascent, these developments are nonetheless troubling. The U.S. must be prepared to protect its own space assets and interests.

Defensive Usage. The U.S. is committed to the exploration and use of space by all nations for peaceful purposes, and for the benefit of all humanity.[117] Advocates for a space weapons capability emphasize that the purpose of those weapons is mainly defensive in nature, providing "big stick" deterrence. However, in cases where deterrence fails, the U.S. requires a capability to deny freedom of action to adversaries in order to protect its own.[118]

Impracticality of Verification. Current policy rejects any limitations on the fundamental right of the U.S. to operate in and acquire data from space.[119] Besides the agreement not to deploy nuclear weapons or any other kinds of weapons of mass destruction in space,[120] the U.S. has refrained from signing any obligations that would further restrict available weapon options. Proponents of weaponizing space argue that arms control agreements are unverifiable and unenforceable and would unacceptably disadvantage the U.S.

Protecting Investments. Developing a capability to control or dominate space is not a new venture for the U.S.[121] From the first days of space flight, military and scientific exploration efforts have been intricately linked. In the last several decades, commercial developments have also become intertwined with other U.S. efforts. The viability and health of the U.S. space industry depends on continued cooperative engagement. Decreasing military efforts excessively could have considerable negative impact in other sectors of the industry.

Preventing the Destructive Use of Space

Opponents of the weaponization of space also stress the criticality of space to U.S. national interests. They stress that it is the growing dependence on space technology and services that should drive the U.S. to the conclusion that it needs to stop pursuing a space weapons capability. Once arms are in space, they argue, it is just a matter of time until they are used, and the consequences will be dire. Therefore, they call for a reversal of current development paths and a treaty-based alternative to space warfare. The following examine the supporting rationale.

Threat – Self-fulfilling Prophesy. Opponents of space weaponization argue that other nations are pursuing space weapon capabilities largely in response to U.S. efforts. Rather than developing military options to protect our space related national interests, the U.S. should denounce space weaponization and lead a supporting international treaty effort.[122] Otherwise, the threat will continue to grow as we continue to build to defend against it.

Defensive Weapons are Offensive. Not everyone is receptive to the characterization of U.S. space weapon development efforts as defensive in nature. Using jamming, kinetic energy kill vehicles, laser energy, or other such mechanisms to destroy the property of another could be construed as offensive.[123] A strategy that calls for cross-domain dominance of air, space, and cyberspace[124] may appear offensive and provocative from another nation's vantage point, fueling the space arms race noted above.[125]

Verification. Many advocates of a space weapons ban concede that it would be very difficult to construct a fully verifiable treaty; however, they highlight the fact that effective treaties already exist that don't require strict verification. A prime example is the Biological Weapons Convention. Those who are more optimistic believe that effective verification measures could be put in place given the proper support and emphasis from the international community, proposing the creation of an international organization to operate in a similar fashion as the International Atomic Energy Association (IAEA) to help police the globe.[126] Opponents to the weaponization of space all argue that results are unachievable without a true effort.

Opportunity Costs. Proponents of international treaties argue that not only does space weaponization result in large costs to the U.S., but it also entails real opportunity costs. An arms race in space could compromise the security of all nations, including the U.S., while it stretches the economic capacities of competitors to the breaking point.[127] In addition to the hundreds of billions, if not trillions of dollars in direct costs, opponents to the weaponization of space highlight a myriad of opportunity costs that make development efforts untenable in their view.

Charting the Course – Policy Options

Policy makers of the next administration will be faced with this lingering issue of whether or not to weaponize space. As examined above, valid arguments and concerns exist both for and against developing a space weapons capability. The following section explores several courses of action available to chart the continuing course into and through space.

Option 1: Return to Port. Develop and promulgate a new U.S. National Space Policy, denouncing space weaponization. Lead an aggressive international effort to ban all further space weapon development. This course of action would be a significant departure not only from the current administration's efforts, but a wholesale change in approach to space. Stock in the United States as the world's benefactor and leader of the free world would sky rocket; however, the associated costs and risks would be considerable. Emerging threats from other nations in space make it imprudent to completely disarm and put all hope and trust in international

cooperation while simultaneously hollowing the U.S.'s industrial base. Yet, arguments proffered by opponents to space weaponization cannot be ignored. Future space policy must attempt to address legitimate concerns raised while still guarding our freedom of action in space.

Option 2: Steady as She Goes. Adopt the current U.S. National Space Policy, and continue efforts to develop and field a space weapons capability. The current course of action postures the U.S. to protect its extensive national vital interests as global competition evolves and to secure continued space operations into the future. As highlighted above, apprehension exists in both the domestic and international arenas over current U.S. policy. Although the U.S. remains committed to the peaceful use of space, there is growing concern that it will do what it wants, when it wants, consequences be damned. Misperceptions must be addressed to increase the effectiveness of its space policy and to help alleviate the possibility of a space war.

Option 3: Pick up Steam. Endorse the current U.S. National Space Policy as a baseline, but expand the guidance to delineate responsibilities of additional U.S. Government entities to enhance the achievement of overall policy objectives. While focusing on how military and economic power will be employed in support of national space objectives, the current policy provides no guidance for employing diplomatic or informational elements to support achievement of national priorities. The issue of space weaponization requires a whole-of-government approach. No policy or strategy for assuring U.S. use of space for national security and economic purposes will be successful without public support.[128] Many of the concerns offered by those opposing the weaponization of space could be addressed through increased engagement from the U.S. Government. The U.S. population needs to understand the extent of U.S. interest in space and the consequences if it is unable to retain its advantage. The international community needs to understand that the U.S. is committed to peaceful space operations. Adding transparency and confidence building in the form of public diplomacy would decrease barriers, and allow the U.S. to proceed… full steam ahead.

In order to protect national interests and investments in space, the current space policy should not only be embraced, but enhanced. Policy option 3 should be adopted. It offers a course that will simultaneously protect the U.S.'s interests and address growing concerns, facilitating smooth, safe sailing in and through space well into the future.

Author: CDR Robert Sharp, USN

CONCLUSIONS AND RECOMMENDATIONS

Mankind is led into the darkness beyond our world by the inspiration of discovery and the longing to understand. Our journey into space will go on.

- President George W. Bush on February 1, 2003[129]

This study of the global space industry, with particular focus on the U.S. and European space markets, found the industry healthy overall. This report reaffirmed America's preeminence among space-faring nations, but it also noted challenges to the U.S. space industry that inhibit it from reaching its full potential. The most pressing challenges were analyzed to draw conclusions and recommend potential courses of action. The following are recommendations for U.S. government leaders to consider.

1. **Recommendations to Improve Funding of U.S. National Security Space Programs**
   - The Congress and the Department of Defense should critically review the requirements for current U.S. national security space programs in early stages of development. They should cancel or modify programs to fit within tighter Defense budgets and leverage commercial capabilities where practical.
   - To provide a more stable funding forecast, the Congress should consider fixing the U.S. National Security Space budget as a percentage of the U.S. gross domestic product.
   - DoD space acquisition managers should build management reserves into new programs.
2. **Recommendations to Increase Support and Funding for U.S. Civil Space Programs**
   - With Congressional action a function of public opinion, the President and NASA should better educate American taxpayers on the tremendous benefits of U.S. space exploration.
   - The next administration should solicit international participation in NASA's Constellation Program.
3. **Recommendations to Reform Export Controls**
   - The Secretary of State should provide enough people and resources to accomplish timely reviews of ITAR license applications or return jurisdiction to the Department of Commerce.
   - The Congress should annually review the U.S. Munitions List to remove technologies that do not pose a real threat to the U.S., or are already available in the global space market.
   - The next administration should negotiate treaties with America's allies that allow for the free exchange of space items and technologies in all but the most critical cases.
4. **Recommendation to Lead International Space Regulatory Reforms**
   - The next administration should lead the world in a discussion about how we collectively operate in space, carefully crafting regulations on space issues, and creating an environment conducive to global prosperity and the advancement of the science of space for the benefit of future generations.
5. **Recommendation to Enhance U.S. Space Policy**
   - To alleviate concerns related to U.S. military efforts in space, the next administration should expand *U.S. Space Policy* with guidance for proactive public diplomacy and strategic communications that explains U.S. intentions regarding military use of space.

Building on past and current progress, the next administration can pick up the torch and light America's way as it leads the world into the vast darkness and promise of space. These recommendations will get the administration started smartly on that journey.

Notes

[1] The Space Foundation, *The Space Report, The Guide to Global Space Activity, 2008; The Executive Summary* (Downloaded May, 2008), http://www.thespacereport.org/08executivesummary.pdf, 6.

[2] Ibid, 6.

[3] Ibid, 6.

[4] These conclusions are based on conversations with industry executives at several visits.

[5] Space Foundation, "Executive Report," *The Space Report 2008; The Authoritative Guide to Global Space Activity*, pg 6. The Space Foundation reported, "Satellite manufacturing revenue increased 14 percent overall to an estimated $13.64 billion. This growth was driven by a 26 percent increase in revenue for government payloads, to $11.41 billion."

[6] Ryan Zelnio, "The Effects effects of Export Controlexport control on the Space Industryspace industry," *The Space Review; Essays and Commentary about the Final Frontier*, January 16, 2006. Taken from: http://www.thespacereview.com/article/533/1. In this article, Zelnio reports, "Prior to the change in export controls in 1999, the US dominated the commercial satellite-manufacturing field with an average market share of 83 percent. Since that time, market share has declined to 50 percent. … since the change in export policy, no Chinese satellite operator has chosen to purchase any satellite that is subject to US export regulations and have instead selected European and Israeli suppliers with over six satellite orders to date since 1999. This comes out to a loss estimated anywhere from $1.5 to $3.0 billion to the US economy." Also, "In addition to the expected movement of Chinese satellite orders from US manufacturers, other operators are increasingly becoming wary of dealing with the U.S. In 2003, Arabsat decided to award two new satellites to Astrium over its traditional builder, Lockheed Martin, due primarily to their fear of export regulations in holding up delivery. Telesat Canada has also tired of the red tape associated with having to deal with ITAR approval and chose to award the Anik F1R satellite to Astrium. Intelsat awarded the contract of Intelsat-10 (originally a two-satellite contract, although one of the two was later cancelled) in 2000 to Astrium fearing the effects ITAR, though they later awarded Intelsat Americas 9 to the US manufacturer Space Systems/Loral in 2004 as part of a deal in purchasing Loral's North American satellite fleet. In addition, US manufacturers are increasingly being weary of bidding on certain foreign contracts. If they anticipate a certain level of ITAR problems, such as was seen on Koreasat 5 with its combined military and civil uses, US companies choose to not even put together competitive bids to win these contracts. In talking with various satellite executives, this is estimated to be around three-to-six non-Chinese contracts since 1999 that have been avoided. Taken in with the losses in the Chinese market described previously, US satellite manufacturers have loss somewhere between $2.5 and $6.0 billion since 1999 due primarily to ITAR regulations."

[7] ESA Website, "What is ESA?," From: http://www.esa.int/SPECIALS/About_ESA/SEMW16ARR1F_0.html. "ESA is an international organisation with 17 Member States. By

coordinating the financial and intellectual resources of its members, it can undertake programmes and activities far beyond the scope of any single European country."

[8] ESA Website, "A European Vision," From: http://www.esa.int/SPECIALS/About_ESA/SEMN5TEVL2F_0.html. "The ESA Convention entered into force on 31 October 1980. Since then, the founding members have been joined by Austria, Finland, Norway and Portugal, and most recently Greece and Luxembourg. Several other European countries have also expressed interest in joining ESA in the near future."

[9] Based on discussions with ESA representatives during visit to ESA Headquarters, Paris, France (May, 14, 2008).

[10] European Centre for Space Law,"Report on the 2007 ECSL Practitioner's Forum", European Centre for Space Law (ECSL), http://www.esa.int/SPECIALS/ECSL/SEM0MNGHZTD_0.html. "[The Coordinator of the Practitioner's Forum, Dr. F.G. von der Dunk (International Institute of Air and Space Law, Leiden University)] said that this year, the Forum will deal with major developments going on within the European space industry environment, relating in particular to the restructuring and consolidation on a corporate level, where we have seen and are still seeing a movement of convergence, joint venturing, takeovers and statutory consolidation."

[11] Futron, *State of the Satellite Industry Report*., prepared for the Satellite Industry Association, June 2006.

[12] Ibid.

[13] Space Foundation, "Executive Report," *The Space Report 2008; The Authoritative Guide to Global Space Activity*. The Space Foundation reports that from 2006 to 2007, "Satellite manufacturing revenue increased 14 percent overall to an estimated $13.64 billion." Also, the *Report* articulates on the expanding commercial nature of the payload sector to support satellite-based services, "The Space Report 2008 also elaborates on the dynamic growth in the space industry's commercial sector. Booming interest in global positioning technology, and industry's rapid expansion of the array of products and services using this technology, have delivered impressive market results. Satellite radio and direct-to-home (DTH) television service are also contributing to substantial growth in the space industry" and "Satellite-related products and services, many of which did not exist just a few years ago, form the largest portion of the space industry, driven primarily by the use of communications and positioning satellites."

[14] European Space Agency website, http://www.esa.int/esaMI/ATV/SEMOP432VBF_0.html (Accessed May 21, 2008).

[15] Ibid.

[16] EUMETSAT website, http://www.eumetsat.int/Home/Main/Media/News/705758?l=en (Accessed May 22, 2008).

[17] Futron Corporation. *State of the Satellite Industry Report*. June 2006. http://www.futron.com/pdf/resource_center/reports/SIA_2006_Indicators.pdf.

[18] Henry R. Hertzfield. *Launch Vehicles: An Economic Perspective*. Space Policy Institute. George Washington University, Washington, DC, September 2005. 11.

[19] Based on discussions with SpaceX executives at their headquarters in Hawthorne, CA on April 7, 2008.

[20] SpaceX website, "NASA Awards Launch Services Contract to SpaceX," April 22, 2008. Taken from: http://www.spacex.com/press.php?page=41.

[21] Carl E. Behrens, *Space Launch Vehicles: Government Activities, Commercial Competition, and Satellite Exports*, Congressional Research Service Report (March 20, 2006). 10. Taken from: http://www.fas.org/sgp/crs/space/IB93062.pdf.

[22] Ibid.

[23] Futron presentation entitled, "*Overview of the Commercial Satellite Industry for the Industrial College of the Armed Forces.*" Delivered February 11, 2008.

[24] Space Foundation, "Executive Report," *The Space Report 2008; The Authoritative Guide to Global Space Activity*, 6.

[25] Ibid, 6.

[26] Ibid, 6.

[27] The following are some of the U.S. agencies having roles in space research, operations, and regulation: National Aeronautics and Space Administration, the Federal Communications Commission, Department of State, Department of Defense, The National Telecommunications and Information Administration of the Department of Commerce, the Federal Aviation Administration's Office of Commercial Space Transportation, the Department of Energy, the Environmental Protection Agency, and National Oceanographic and Atmospheric Administration.

[28] "Department Organization," *Executive Office of the President, Office of Science and Technology Policy* (Accessed March 23, 2008), http://www.ostp.gov/cs/about_ostp.

[29] *The National Aeronautics and Space Act*. Public Law Number 85-568, 72 Statute 426 (July 29, 1958), As Amended. *National Aeronautics and Space Administration*. http://www.nasa.gov/offices/ogc/about/space_act1_prt.htm, Section 102.

[30] NASA, " – What Does NASA Do?"?, http://www.nasa.gov/about/highlights/what_does_nasa_do.html.

[31] NASA, “Centennial Challenges: NASA's Prize Program for the Citizen Inventor.” Taken from: http://centennialchallenges.nasa.gov/.

[32] Euroconsult 08 Executive Summary.

[33] Ibid.

[34] NASA, “NASA Invests in Private Sector Space Flight with SpaceX, Rocketplane-Kistler,” August 18, 2006. Taken from: http://www.nasa.gov/mission_pages/exploration/news/COTS_selection_prt.htm.

[35] Ibid.

[36] European Space AgencyESA Website, “Vega,” January 21, 2008. Taken from: http://www.esa.int/SPECIALS/Launchers_Access_to_Space/ASEKMU0TCNC_0.html.

[37] The European Space Agency. ESA Launchers. http://www.esa.int/SPECIALS/Launchers_Home/SEMNCI1PGQD_0.html.

[38] Kayser-Threde Website, “Press Conference on November 29, 2007 at Kayser-Threde, Munich On-Orbit Life Extension of Satellites: SMART-OLEV.” Taken from: http://www.kayser-threde.de/en/press/news_detail.php?id=172.

[39] “Space Robotics,” DLR – Institute of Robotics and Mechatronics, “Space Robotics,” Found at: http://www.dlr.de/rm-neu/en/desktopdefault.aspx/tabid-3794/.

[40] European Space Agency, “Galileo,” website, http://www.esa.int/esaNA/galileo.html (accessed May 21, 2008).

[41] European Space Agency, “ATV” website, http://www.esa.int/esaMI/ATV/SEMOP432VBF_0.html (accessed May 21, 2008).

[42] Based on discussions with executives and engineers at the Deutsches Zentrum für Luft und Raumfahrt (DLR - German Space Agency) on (8 May 8, 2008), Oberpfaffenhofen, Germany.

[43] Northrop Grumman Website, “Northrop Grumman Completes Acquisition of Scaled Composites, LLC,” August 24, 2007. Taken from: http://www.irconnect.com/noc/press/pages/news_releases.html.

[44] Surrey Satellite technology, Ltd. Website, “EADS Astrium signs an agreement to acquire SSTL,” April 7, 2008. Taken from: http://www.sstl.co.uk/index.php?loc=6.

[45] Futron Corporation,. “*Suborbital Space Tourism Demand Revisited.*” (August 24, 2006), http://www.futron.com/pdf/resource_center/white_papers/SpaceTourismRevisited.pdf, 4.

[46] Ibid, 5.

[47] Ibid.

[48] *Virgin Galactic*, http://www.virgingalactic.com/flash.html?language=english.

[49] Futron Corporation, *New Mexico Commercial Spaceport Economic Impact Study*, 4.

[50] David Walker, "Making Tough Budget Choices for a Better Future," presentation to ICAF, (March 12, 2008): slide 4.

[51] Ibid.

[52] Democratic Staff Senate Budget Committee, "CBO budget reports shows deteriorating long term picture," CBO *Fact Sheet* (January 24, 2007), 2.

[53] Michael Griffin, "Statement before the Subcommittee on Space, Aeronautics and Related Sciences," (February 27, 2008). www.nasa.gov/pdf/115069main_mg_senate_051205.pdf.

[54] Warren Leary, "Unexpected Costs Force NASA Cuts," New York Times (February 7, 2006): 15.

[55] Michael Griffin, *Issues Facing the U.S. Space Program After Retirement of the Space Shuttle*.

[56] "Statement of Michael D. Griffin Administrator, National Aeronautics and Space Administration before the Committee on Science & Technology," U.S. House of Representatives FY 2009 Budget Hearing, 13 February 2008. 3.

[57] International Traffic in Arms Regulations, 22 C.F.R. §120-130 (2006).

[58] U.S. Air Force and Department of Commerce, Defense Industrial Base Assessment: U.S. Space Industry Final Report, (31 August 2007, Dayton, Ohio). This data was collected as part of a Department of Commerce (DOC), Bureau of Industry and Security (BIS) study, which developed, deployed, and verified data collection from a survey of space industry companies. National Security Space Office (NSSO) served in an oversight capacity. The study involved a broad look at industrial base indicators and a detailed analysis of the BIS survey inputs. The BIS issued the survey electronically on February 2, 2007 and concluded it on April 24, 2007. The survey was sent to 274 space industry company/business units — the BIS received and verified 202 survey inputs for a 74% response rate. Conclusions also derived from discussions with representatives of the international space industry. See page ii, this report.

[59] Patricia Moloney Figliola, *U.S. Military Space: Status of Selected Programs*, Congressional Research Service, (June 4, 2007): 1.

[60] Robert Levin, *Military Space Acquisition*, Govt Accountability Office, GAO: 2.

[61] Subcommittee of Defense, House Committee on Appropriations, *Defense Acquisitions: Incentives and Pressures that Drive Problems Affecting Satellite and Related Acquisitions (GAO-05-570R)*, June 23, 2005: 10.

[62] Pedro L. Rustan, "How to Solve U.S. Space Acquisition Problems," *Aviation Week & Space Technology* 163, no. 9 (09/05, 2005), http://ezproxy6.ndu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=mth&AN=18237138&site=ehost-live: 1.

[63] Committee on Commerce, Science and Transportation, *Issues Facing the U.S. Space Program After Retirement of the Space Shuttle*, 2007, , http://legislative.nasa.gov/hearings/11-15-07%20Griffin.pdf (accessed 27 February, 2008).

[64] National Aeronautics and Space Administration, "Constellation Program Status Brief" ICAF Space Industry Visit to NASA 14 March, 2007.

[65] Rhatigan, *Formulation of NASA's Constellation Program*, 11.

[66] NASA briefed ICAF Space Industry Studies class that they intend to provide the transportation to and from the Moon and Mars but expect international partners to pick up the bill for surface exploration.

[67] Paul Marks, "NASA Seeks Help for Human Exploration of Mars," NewsScientistSpace, http://space.newscientist.com/article.ns?id=dn9582&print=true (accessed 16 Mar, 2008, 2008).

[68] Francois Murphy, "France's Sarkozy Calls for World Mission to Mars," *Reuters Online* (2008), http://www.reuters.com/article/rbssIndustryMaterialsUtilitiesNews/idUSL1169701020080211. Recently, France showed its support for such efforts when President Nicolas Sarkozy also called for an international effort to jointly explore Mars.

[69] Gregory P. Metzler, "China in Space: Implications for U.S. Military Strategy", Joint Forces Quarterly, (Issue 47, 4th Quarter 2007), 96.

[70] *See, e.g.*, Christopher F. Corr, "*The Wall Still Stands! Complying with Export Controls on Technology Transfers in the Post-Cold War, Post-9/11 Era*," 25 HOUS. J. INT'L L. (2003), 441, 443-46 (2003); Gregory W. Bowman, "*E-mails, Servers, and Software: U.S. Export Controls for the Modern Era*," 35 GEO. J. INT' L, (2004),. 325-26. (2004) Daniel H. Joyner, "*The Enhanced Proliferation Control Initiative: National Security Necessity or Unconstitutionally Vague*?*"*, 32 GA. J. INT'L & COMP. (2004),L. 107, 112-15 (2004). Reported by John R. Liebman & Kevin J. Lombardo, "*Guide to Export Controls for the Non-Specialist*," 28 LOY. L.A. INT'L & COMP. L., (REV. 497 (Summer 2006).

[71] "*The Growth Competitiveness Index: Analyzing Key Underpinnings of Sustained Economic Growth*," at http://www.weforum.org/pdf/Gcr/GCR_2003_2004/GCI_Chapter.pdf (*last accessed* 30 March 2008).

[72] "U.S. Department of Commerce's Commercial Services", http://www.export.gov/about/benefits_exporting.asp. 95 percent of the world's consumers live outside of the United States, so if a U.S. business is only selling domestically; it is reaching just a small share of potential customers. Exporting enables companies to diversify their portfolios and to weather changes in domestic economy. *See*, web site at the U.S. Department of Commerce's Commercial Services at http://www.export.gov/about/benefits_exporting.asp (last accessed 30 March 2008).

[73] "Regulating Satellite Exports," Center for Strategic and International Studies (CSIS), *Regulating Satellite Exports*, May 2003, p1, at http://www.csis.org/media/csis/pubs/030502_regulating_satellite_exports.pdf (last accessed 30 March 2008).

[74] "*AIA, EIA, NDIA Call On Bush To More Rapidly Reform Export System,"* DEFENSE DAILY INTERNATIONAL, (Feb 8, 2002), , Vol. 3, Iss. 14, 1.

[75] Ibid, 1.

[76] "Regulating Satellite Exports," *Center for Strategic and International Studies (CSIS*), *Regulating Satellite Exports*, May 2003, 1, http://www.csis.org/media/csis/pubs/030502_regulating_satellite_exports.pdf (last accessed 30 March 2008).

[77] Ibid.

[78] Christopher F. Corr, "The Wall Still Stands! Complying with Export Controls on Technology Transfers in the Post-Cold War, Post-9/11 Era," *25 HOUS. J. INT'L L*. (2003), 441, 443-46. Gregory W. Bowman, "E-mails, Servers, and Software: U.S. Export Controls for the Modern Era," *35 GEO. J. INT' L*, (2004), 325-26. Daniel H. Joyner, "The Enhanced Proliferation Control Initiative: National Security Necessity or Unconstitutionally Vague?*", 32 GA. J. INT'L & COMP*. (2004), 107, 112-15. John R. Liebman & Kevin J. Lombardo, "Guide to Export Controls for the Non-Specialist," *28 LOY. L.A. INT'L & COMP. L.,* (2006).Many of these export controls also apply extraterritorially so a company's foreign affiliates, divisions, and subsidiaries must also comply with U.S. export controls on exports, imports, re-exports (see note following) and re-transfers of products and technical data, services rendered to foreigners, financial transactions with designated countries. Reexport or retransfer means the transfer of products or services "to an end-use, end-user or destination not previously authorized." 22 C.F.R. §120.19 (2006). Typically, this occurs when a company properly exports an item to a foreign country, then "reexports" the item to another country without proper authorization. *See, e.g., Christopher F. Corr, The Wall Still Stands! Complying with Export Controls on Technology Transfers in the Post-Cold War, Post-9/11 Era, 25 Hous. J. Int'l L. 441, 443-46 (2003); Gregory W. Bowman, E-*

mails, Servers, and Software: U.S. Export Controls for the Modern Era, 35 Geo. J. Int' L. 325-26 (2004); Daniel H. Joyner, The Enhanced Proliferation Control Initiative: National Security Necessity or Unconstitutionally Vague?, 32 Ga. J. Int'l & Comp. L. 107, 112-15 (2004). Reported by John R. Liebman & Kevin J. Lombardo, Guide to Export Controls for the Non-Specialist, 28 Loy. L.A. Int'l & Comp. L. Rev. 497, 499 (Summer 2006).

[79] It considers such factors as: destination; end-user; the product; and its end-use in making the export license determination.

[80] International Traffic in Arms Regulations, 22 C.F.R. §120-130 (2006).

[81] Export Administration Regulations, 15 C.F.R. §730-774 (2006).

[82] *See* 22 C.F.R. §120.2 (2006).

[83] Ibid. §121.1; Amendments to the International Traffic in Arms Regulations (ITAR): Control of Commercial Communications Satellites on the United States Munitions List, 64 Fed. Reg. 13,679, 13,680 (Mar. 22, 1999).

[84] The United States Munitions List, 22 C.F.R. §121.1 (2006). The USML is part of the ITAR. 22 C.F.R. §§120-130 (2006).

[85] One of which is not currently assigned.

[86] 22 C.F.R. §121.1 (Category IV).

[87] 22 C.F.R. §121.1 (Category XV).

[88] *See* Philip S. Rhoads, "*The International Traffic in Arms Regulations: Compliance and Enforcement in the Directorate of Defense Trade Controls U.S. Department of State,*", reprinted in COPING WITH U.S. EXPORT CONTROLS 2003; EXPORT CONTROLS & SANCTIONS: WHAT LAWYERS NEED TO KNOW. , *See* John R. Liebman, "Product Classification and Regulatory Compliance,", *reprinted in* Coping with U.S. Export Controls 2003; Export Controls & Sanctions: What Lawyers Need to Know., Donald W. Smith, "Defense of Export Control Enforcement Actions," *Practicing, 615-16 (Practising Law Institute, 2003) at* 500, 583, 593-94, 615-16.

[89] The ITAR also provides for various exclusions and exemptions, but these limited exemptions and exclusions are quite specific and beyond this discussion. However, what is excluded or exempted from licensing under ITAR is generally subject to the EAR.

[90] *Compare* 15 C.F.R. §772.1 *("Export means actual shipment or transmission of items out of the United States."*), with 22 C.F.R. §120.17(a)(1) *("Export means ... taking a defense article out of the United States in any manner ... .")*. *From* Benjamin Carter Findley, "Comment: Revisions to the United States Deemed-Export Regulations: Implications for Universities,

University Research, and Foreign Faculty, Staff, and Students,", 2006 *Wis. L. Rev.* 1223, 1229, footnote 12.

[91] John R. Liebman & Kevin J. Lombardo, *Guide to Export Controls for the Non-Specialist*. In slight contrast to the ITAR definition of "export," the EAR defines export as "an actual shipment or transmission of items [including technology or software subject to the EAR] out of the United States." 15 C.F.R. §772.1. Compare 15 C.F.R. §772.1 ("Export means actual shipment or transmission of items out of the United States."), with 22 C.F.R. §120.17(a)(1) ("Export means ... taking a defense article out of the United States in any manner . It also provides that "any release of technology ... subject to the EAR to a foreign national ... is deemed to be an export to the home country ... of the foreign national." 15 C.F.R. §734.2(b)(2)(ii).

[92] This was originally authorized by the Export Administration Act (EAA), 50 U.S.C. App. §§2401-2420 (2000) (expired Aug. 20, 2001) but is presently authorized by the International Emergency Economic Powers Act (IEEPA), 50 U.S.C. §§1701-1706 (2000).

[93] 15 C.F.R. §738.1.

[94] 15 C.F.R. §§738.1, 738 supp. 1.

[95] The subcategories of EAR controlled technologies are: (A) Equipment, Assemblies and Components; (B) Test, Inspection and Production Equipment; (C) Materials; (D) Software; and (E) Technology. In each category there are descriptive subcategories (groups) and for each item a Export Control Classification Number ("ECCN") which identifies the item by category, group, and reason for control. The EAR also provides ten general prohibitions that describe specific scenarios under which a license is required. The ten general prohibitions are: *See* 15 C.F.R. §736.2(b)(1) (Export and reexport of controlled items to listed countries), §736.2(b)(2) (Reexport and export from abroad of foreign-made items incorporating more than a *de minimus* amount of controlled U.S. content), §736.2(b)(3) (Reexport and export from abroad of the foreign-produced direct product of U.S. technology and software), §736.2(b)(4) (Engaging in actions prohibited by a denial order), §736.2(b)(5) (Export or reexport to prohibited end-uses or end-users), §736.2(b)(6) (Export or reexport to embargoed destinations); §736.2(b)(7) (Support of proliferation activities), §736.2(b)(8) (In transit shipments and items to be unladen from vessels or aircraft), §736.2(b)(9) (Violation of any order, terms, and conditions), and §736.2(b)(10) (Proceeding with transactions with knowledge that a violation has occurred or is about to occur). Through this intricate classification process in the EAR's Commerce Control List (CCL) and Commerce Country Chart (CCC), a control matrix emerges that determines whether a given commodity and its related production equipment, technical information, and software must be licensed by Commerce before it may be lawfully exported from the U.S. (or reexported by the foreign customer who previously acquired the commodity). The matrix reveals that the level of control applied is determined by four factors: (i) the level of technological sophistication of the commodity, (ii) the commodity's potential for becoming the foundation of more advanced technology, (iii) the commodity's end-use, and (iv) the end-user to whom the exporter desires to send the commodity. To add further complication, the ITAR and EAR are not limited to U.S. companies. These export controls apply not only to the export items

but also to the technologies embodied in those items. The ITAR and EAR follow the products and apply also to the systems or products the original ITAR or EAR controlled item becomes a component of. Liebman, 508-509.

[96] 15 C.F.R. §738.2(a).

[97] John Hillery, "U.S. Satellite Export Control Policy," CSIS Commentary, (September 20, 2006).

[98] Ibid.

[99] "U.S. Air Force and Department of Commerce, Defense Industrial Base Assessment: U.S. Space Industry Final Report," *U.S. Air Force and Department of Commerce* (, (31 August 2007, Dayton, Ohio).

[100] Ibid.

[101] The Aerospace Industries Association, the Electronic Industries Alliance, and the National Defense Industrial Association wrote the following to President Bush in 1992:

> In our view, major changes to the U.S. export control regime are required to ensure that it reflects both current global market realities and America's strategic policy imperatives ... America's advanced technology industries -- aerospace, telecommunications, information, and defense--are uniquely aligned with our strategic national interests. … We also strongly believe that export control reform does not require 'choosing' between our national security and economic interests. The fact is that our national security is inextricably linked to our technological leadership--indeed, that leadership assures the primary military advantage we possess over the opponents our nation confronts today. As a consequence, it is critical that export controls effectively deny our adversaries access to truly critical capabilities and ensure continued U.S. technological leadership. "

AIA, EIA, NDIA Call On Bush To More Rapidly Reform Export System,"; DEFENSE DAILY INTERNATIONAL, (Feb 8, 2002), Vol. 3, Iss. 14, 1.

[102] John Hillery, "U.S. Satellite Export Control Policy," *CSIS Commentary*, (2006).

[103] 22 C.F.R. §120.3 (2006). Articles or services that do not meet this test, but that have the capability for dual use are controlled by Commerce under the EAR. Reported in Liebman, supra note 3 at 503. Also included are technical data and defense services that are "directly related to the defense articles enumerated in the previous definition of defense articles." The categories include a miscellaneous category for articles not specifically enumerated in any other Munitions List category but having a substantial military application and which have been designed or modified for military purposes. 22 C.F.R. §121.1 at Category XXI ("Miscellaneous Articles").

[104] United Nations, Office of Outer Space Affairs, "United Nations Treaties and Principles on Outer Space and Related General Assembly Resolutions," United Nations, Office

of Outer Space Affairs, Vienna International Center, P.O. Box 500, 1400 Vienna, Austria, http://www.unoosa.org/pdf/publications/ST_SPACE_11_Rev2_Add1E.pdf (accessed 03/30, 2008). and "'United Nations Treaties and Principles on outer space and related General Assembly resolutions,"' http://www.unoosa.org/pdf/publications/ST_SPACE_11_Rev2_Add1E.pdf.

[105] There are several multilateral agreements with more limited scope concerning space. The first is the multilateral treaty for the 'Arrangement concerning the application of the Space Station intergovernmental agreement pending its entry into force' was entered into force January 29, 1998 and it included Canada, Denmark, Germany, Netherlands, Norway, Russian Federation, Spain, Sweden, United Kingdom and the United States.'[105] A later annex to the above is the multilateral treaty for the 'Agreement concerning cooperation on the civil International Space Station, entered into force March 27, 2001 and included Canada, Japan, Russian Federation and the United States.'[105] The multilateral treaty for 'Memorandum of understanding for the cooperation in the ocean surface topography mission was entered into force April 7, 2006 and included EUMETSAT (European Organization for the Exploitation of Meteorological Satellites), France and the United States.[105] As of November 1, 2007 the United States has a number of bilateral space treaties in force with a number of countries.[105]

[106] Jerry Jon Sellers, 'Understanding Space', Third Edition, Jerry Jon Sellers, McGraw-Hill Companies (2005), ch 16, 668.

[107] The following U.S. agencies have a key role in regulating and implementing space law: National Aeronautics and Space Administration, the Federal Communications Commission, Department of State, Department of Defense, The National Telecommunications and Information Administration of the Department of Commerce, the Federal Aviation Administration's Office of Commercial Space Transportation, the Department of Energy, the Environmental Protection Agency, and National Oceanographic and Atmospheric Administration.

[108] William L. Shelton, Commander, Maj Gen, USAF, 14th Air Force, *" 23rd National Space Symposium*," http://www.afspc.af.mil/library/speeches/speech.asp?id=316, (accessed 23 March 08).

[109] Executive Summary of *Findings from the Report of the 'Commission to Assess United States National Security Space Management and Organization'*, 30 Findings from the Report of the 'Commission to Assess United States National Security Space Management and Organization', Pursuant to Public Law 106-65, January 11, 2001, Executive Summary p vii http://space.au.af.mil/space_commission/chapters/exec_sum.pdf.

[110] Ken Fireman and Tony Capaccio, "U.S. Missile Hits Spy Satellite Carrying Toxic Fuel." *Bloomberg News*, February 21, 2008. See also, Steven Lee Meyers, "Look Out Below. The Arms Race in Space May Be On." *New York Times*, March 10, 2008. These are but two of many representative articles that reported details of the event. The shoot down was covered widely in open source news reports domestically and internationally.

[111] Helen Caldicott, and Craig Eisendrath, *War in Heaven* (New York: The New Press, 2007), xv.

[112] United States National Security Presidential Directive 49. "U.S. National Space Policy." August 31, 2006, 1.

[113] International Security Advisory Board, "Report on U.S. Space Policy." (25 April, 2007), 1, 7.

[114] Ibid, 4.

[115] Steven Lee Meyers, "Look Out Below. The Arms Race in Space May Be On," *New York Times*, March 10, 2008, 1.

[116] Ibid, 1. Additional related developments were reported by Theresa Hitchens, "Space Wars – Coming to the Sky Near You?" *Scientific American Magazine*, February 18, 2008, 2-3: The test of their direct-ascent anti-satellite (ASAT) missile came on the heels of press reports in September 2006 that the Chinese had also managed to "paint" or illuminate U.S. spy satellites with a ground based-laser. Other states may similarly be pursuing weapons capabilities in space. U.S. Defense News quoted unidentified Indian defense officials as stating that their country had already begun development of their own kinetic-energy and laser-based ASAT weapons. If India starts to develop a capability, there's a high likelihood that Pakistan would follow suit.

[117] United States National Security Presidential Directive 49. "U.S. National Space Policy." August 31, 2006, 1.

[118] Ibid, 4. Of note, the 1996 National Space Policy directive included similar language, requiring that the United States be able to "deny, if necessary, adversaries the use of space capabilities hostile to U.S. national interests."

[119] Ibid, 1.

[120] United Nations. "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies: U.N. Resolution 2222." January 27, 1967, Article IV.

[121] Caldicott and Eisendrath, *War in Heaven*, (New York: The New Press, 2007), 66.

[122] Mike Moore, "Arms Race in Space?" *San Francisco Chronicle*, 12 February, 2008.

[123] Caldicott and Eisendrath, *War in Heaven*, (New York: The New Press, 2007), 85.

[124] United States Air Force. "The Nation's Guardians: America's 21st Century Air Force. CSAF White Paper." December 29, 2007. This white paper documents U.S. Air Force's

strategy for the next two decades and defines their role in promoting and defending the national interest.

[125] Caldicott and Eisendrath, *War in Heaven*, (New York: The New Press, 2007), 85.

[126] Ibid, 123.

[127] Theresa Hitchens, “Space Wars – Coming to the Sky Near You?” Feb 18, 2008, 6.

[128] International Security Advisory Board, “Report on U.S. Space Policy.” April 25, 2007, 10.

[129] Reingold, *Columbia Accident Investigation Report*, *Volume I*; Part 1, ch 9.3 (Final Conclusions), 211.

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